Sternocœlis Lewisi, Reit. Wien. ent. Zeit. ii. p. 143	1883	Europe.
Reit. Deutsche ent. Zeitschr. xxviii. p. 75, pl. i. fig. 4	1884	
—— extructisternum, Lewis, n. sp.	1888	Algeria.
—— grandis, Reitter, Wien. ent. Zeit. ii. p. 143	1883	Europe.
—— lævidorsis, Fairm. Pet. Nouv. ii. n. 148, p. 37	1876	Algeria.
—— incisus, Schmidt, Deutsch. ent. Zeitschr. xxix. p. 440	1885	Europe.
—— pluristriatus, Fairm. Pet. Nouv. n. 163, p. 98	1877	Algeria.
—— fusculus, Schmidt, Ent. Nachrichten	1888	Europe.
—— mauritanicus, Lewis, n. sp.	1888	Morocco.
—— pectoralis, Lewis, n. sp.	1888	Algeria.
—— Marseuli, Bris. Ann. Soc. Ent. Fr. p. 367	1866	Europe.
SATRAPES, Schmidt, Deutsch. ent. Zeitschr. xxix. 1885. (Type *talyschensis.*)		
—— Sartorii, Redtenb. Fn. Austr. p. 311	1858	Europe.
Rayei (Eretmotus), Mars. Abeille, i. p. 348	1864	
—— Reitteri, Lewis, n. sp.	1888	Europe.
—— talyschensis, Reitter, Wien. ent. Zeit. ii. p. 143	1883	Europe.

Note.—An asterisk is attached to the species I have not seen. If naturalists who go to mountainous places and remote forest-lands to collect insects will pay attention to this class of beetles, the number in our cabinets will be quickly doubled.

XIX.—*Biological Studies of Protista.*

By Dr. MAX VERWORN *.

[Plate IX.]

I MADE the following researches on Protista when, for the purpose of certain psychophysiological investigations which will hereafter be published in their entirety, I set myself the task of observing the process of shell-formation in the shelled freshwater Rhizopoda. In the case of those forms which build their shells with materials produced by themselves this process has been described and illustrated with figures in previous memoirs, especially by Gruber †, and recently in a very detailed fashion by Schewiakoff ‡; and therefore my

* Translated from the 'Zeitschrift für wissenschaftliche Zoologie,' Band xlvi. pp. 455–470, with a plate.

† A. Gruber, "Der Theilungsvorgang bei *Euglypha alveolata*," in Zeitschr. f. wiss. Zool. Bd. xxxv., and "Die Theilung der monothalamen Rhizopoden," *ibid.* Bd. xxxvi.

‡ W. Schewiakoff, "Ueber die karyokinetische Kerntheilung von *Euglypha alveolata*," in Morph. Jahrb. Bd. xiii.

endeavour was to observe it in a form which employs foreign bodies in the construction of its shell. For this I selected a *Difflugia*. By the observations that I made upon this form I was then induced to include a marine Polythalamous form (*Polystomella*) in the range of my studies, and I am indebted to the kindness of Prof. F. E. Schulze for having the necessary material placed at my disposal.

Difflugia urceolata, Carter.

In an aquarium with water from the Halensee, near Berlin, which had stood in the Berlin Zoological Institute since the end of June 1887, numerous individuals of *Difflugia urceolata*, Carter, made their appearance towards the end of October, and these, from their large size, furnished me with favourable material for my investigations. In order to guard against any sudden extermination of this brood of Protista in consequence of unfavourable influences in the aquarium, I separated from it several smaller cultures by distributing many examples with portions of the bottom and aquatic plants in small glasses which I kept in moist chambers. On examining one of these small glasses in the morning of November 9, I found two individuals engaged in conjugation. Any mistake as to a process of division was here excluded, as the shells of both individuals from the commencement of the observation were perfectly black, and by transmitted light both appeared uniformly reddish brown. The two Protista lay with their shell-openings so brought together that their margins were exactly opposite each other, only upon one side there was a narrow fissure between them, from which numerous pseudopodia were protruded. The pair were isolated and kept in a watch-glass. On the morning of the 10th November all the pseudopodia were retracted, and the shells lay immovably with the two openings pressed exactly together. The Protista remained in this state throughout the day. On November 11, in the morning, a small fissure had again been produced between the mouths of the two shells, and through this, as on the first day of observation, numerous pseudopodia issued. As I assumed that the conjugation-process would soon be completed I killed the Protista with osmic acid in the course of the day, when the pseudopodia remained exserted, and stained them with ammonio-picrocarmine. It now appeared that during the staining the two shells had separated from each other, by which a glance into the nature of the protoplasm was rendered

possible. The protoplasm had protruded somewhat, and it was distinctly observable that the protoplasmic bodies of the two individuals had become fused into one, in such a manner that the hyaline protoplasm with the pseudopodia formed a circlet surrounding, like a girdle, the endoplasm, which extended into both the shells. I was then astonished to see that in the endoplasm, besides a dark mass consisting chiefly of sand-grains, there were about thirty or thirty-five nuclei of 0·2 millim. in diameter, which presented the ordinary appearance of Difflugian nuclei and appeared of a dark red colour. At first I thought that the appearance of these numerous nuclei must be connected with the conjugation-process, until I ascertained from the examination of other individuals, taken from different glasses and at different times, that all the individuals always contained from fifteen to twenty nuclei, and that, consequently, *Difflugia urceolata* is a multinucleated form. One specimen, from which one side of the shell has been separated under the microscope by means of a very pointed and sharp lancet, is shown in Pl. IX. fig. 2. Within the shell will be observed the greyish-brown endoplasm, which owes its characteristic colour to innumerable very small brownish granules with strong refractive power. In it lie the nuclei (the dark spots in the figure), together with nutritive particles, and finally a great number of sand-grains, the latter partly only adherent, but partly also completely immersed in the protoplasm. In the neighbourhood of the aperture is the hyaline exoplasm, which extends outwards its finger-like pseudopodia.

My interest was most excited by the accumulation of sand-grains which occurred in the endoplasm of the *Difflugia*; and as I found this to be a pretty regular constituent in the protoplasm of all the specimens examined, I supposed that it was employed in the formation of the shell. Bütschli * has already indicated the probability that "the foreign material applied to the construction of the shell was taken up into the protoplasmic body-mass of the *Difflugia* itself and subsequently deposited at the surface for the formation of the shell." Gruber † adopts Bütschli's suggestion, and with reference to the frequently observed phenomenon that other Rhizopoda take up sand into their protoplasmic body-mass he says:—"Scarcely any doubt will remain that Bütschli's opinion with regard to the Difflugian shell is correct, and consequently these animals *themselves* will *select and take up* into themselves

* In Bronn's 'Klassen und Ordnungen des Thierreichs,' Protozoa (1880).

† "Die Theilung &c.," *loc. cit.*

from the water the material, the sand, the Diatomeæ, or whatever it may be. If they then proceed to divide, this and the foundation of the new shell takes place in the same way as in the before-mentioned Monothalamia" (*Euglypha*, *Quadrula*, *Cyphoderia*, &c.).

I now endeavoured in the first place to observe directly the act of inception of sand. For this purpose it was advantageous to furnish the Protista with as much shell-material as possible, in order to give them abundant opportunities of taking it into them. In order that it might be readily recognizable and distinguishable from other materials in my investigations I did not employ sand-grains, but finely-powdered dark blue glass, the smallest fragments of which certainly appeared very clear, although in contrast with the surroundings they always showed a faint bluish tinge. In subsequent experiments I used perfectly black glass, the finest particles of which appeared olive-coloured. After putting a suitable quantity of blue glass-fragments into a watch-glass, I introduced several *Difflugiæ* with water-plants. In a short time the Protista began to extend pseudopodia and to creep about among the powdered glass. They often touched the glass-fragments with their pseudopodia, but pushed them away and crept past without incepting them. I observed them for a very long time and repeatedly; but at first I did not succeed in observing any inception of the glass-granules. Then it chanced that a clumsy *Cypris* came near a *Difflugia* and pushed roughly against its pseudopodia. In a few seconds the surface of the widely extended pseudopodia became wrinkled and knobbed, and some glass-granules remained adhering to them, which were then gradually retracted, together with the pseudopodia, completely into the interior of the shell. This, therefore, was the mode in which the inception of shell-material takes place; by mechanical irritation a reflex contraction of the pseudopodia is produced, and combined therewith a secretion of a sticky coat on their surface, which enables the glass-granules to adhere to the pseudopodia and to be drawn in with them. By a series of experiments, which were repeated upon other species of *Difflugia*, I then ascertained the great regularity of this process. When a *Difflugia* had extended its pseudopodia to a great length and was creeping about between the glass plates, it was irritated with a sharp needle. The same effect was then produced with great exactness; the pseudopodia became tubercular, and while previously no glass-granules were adherent to them, these now clung firmly and were slowly retracted into the shell. Specimens of which the shells were partially removed

then showed that the glass-grains not only remained adherent to the surface of the protoplasm, but were actually drawn into it, so that the interior contained a quantity of blue glass-grains.

The mode in which the material for the construction of the shell was taken up was therefore ascertained; but it was some time before I succeeded in discovering individuals engaged in division. I found these in a watch-glass which contained a brood separated from the larger aquarium, but unfortunately only of a few individuals. Nevertheless I had the opportunity of observing different stages of the process of division, and thus of ascertaining that the process is effected in precisely the same way that was accepted by Gruber with regard to the division of *Euglypha*, *Cyphoderia*, &c. First of all there protrudes from the shell-apertures a round, low mound of protoplasm, which issues further and further, and the convexity of which gradually approaches the spherical form. In one instance its form appeared not to be quite regular, but somewhat oblique and impressed on one side. In a further advanced stage the protruded mass of protoplasm had already attained the size of the original individual, and I even found a specimen in which it was somewhat larger and broader than the latter. In an individual whose protruded mass had already approximately acquired the size of the old shell, I observed that a ball of glass-granules had already in part entered the newly formed half, in which the protoplasm with the glass-grains showed a slowly flowing movement (Pl. IX. fig. 1). In the most advanced stage of division the protruded protoplasm had already assumed pretty nearly the form of a Difflugian shell of the present species, and the particles of glass had arranged themselves at its surface. The new half seemed not yet to have a solid shell; but the glass-granules were loosely fitted to one another. On the following day in this specimen the separation of the newly-formed individual was completed, and it was creeping about in the watch-glass with its pseudopodia. Its shell showed the characteristic form, but the pale bluish glass-grains were united to each other by a nearly transparent, but, at any rate, quite colourless connective substance, which only some days later began to acquire a darker brownish colour. Together with this specimen there were on the next day two likewise newly formed individuals which had the same appearance. The other four specimens which I had found engaged in division on the previous day showed scarcely any noticeable alteration since I had left them, and afterwards it turned out that they were dead. The subsequent attempt at nuclear staining was

unsuccessful, and only in one individual there was to be seen in the protruded protoplasmic mass a single, very large, but not particularly distinct nucleus; so that from this it is not possible for me to say anything about the behaviour of the nuclei during division. As appears from the observations on *Difflugia*, this genus therefore, as regards the shell-formation during division, approximates directly to the other shelled freshwater Rhizopoda.

To ascertain whether and in what manner the *Difflugia* repairs artificial injuries of its shell by means of the building-material taken up into the protoplasm, I made a series of experiments by division. When the individuals had completely withdrawn into their shells they were cut up with a sharp lancet in definite directions under the microscope, and then preserved in watch-glasses or upon object-slides with the necessary shell-material. They all supported the operation well, and could be kept alive for more than three weeks even upon the object-slide if they were preserved in moist chambers.

First of all the Protista were divided into two portions of nearly equal size by a cut through the middle of the animal in the plane of the shell-aperture (fig. 3, *a*). The divided pieces were carefully examined every day. They appeared quite normal, extended their pseudopodia, and crept about. When irritated they reacted as before, and took up glass-granules, but they showed no regeneration of the shell; the cut margins remained about as irregular as soon after the section. Other individuals were divided into two equal parts by a cut made in the longitudinal direction of the shell (fig. 3, *b*). These portions also were quite normal in their behaviour, but without regenerating the shell. Next specimens were cut into two unequal parts both transversely and longitudinally; but neither the larger nor the smaller divisions showed any alteration at the cut portions of the shell. The experiments were varied in the most multifarious manner (fig. 3, *c*) in a very great number of specimens, but always with the same result; all the fragments still retained the same vitality, but without regenerating the portions of shell which remained to them.

I then modified the experiment by inflicting only quite small injuries, without injuring the protoplasmic body. For this purpose I made small incisions in different parts of the shell of many individuals, and watched whether these would be repaired. Every day a careful examination was made to see whether any change had taken place; but even after the lapse of three weeks the cut parts showed

exactly the same appearance as immediately after the operation. The cut margins remained just as irregular as on the first day, and although all the individuals had taken up glass-granules, no deposition of them had occurred at the point of lesion. The experiments were afterwards made with other glass-particles and with sand-grains, but no repair or completion of the shell ever occurred.

Finally, the whole shell was removed from some specimens under a low power, without inflicting any injury upon the protoplasmic body of the Protistan. In this way I obtained perfect *Difflugiæ* without shells, which also behaved quite normally. They took up sand-grains (or glass-particles), crept about with their finger-like pseudopodia, and frequently flattened themselves out, when it was particularly easy to see that the incepted glass-granules formed a small aggregation in the interior of the protoplasm. When only short pseudopodia were emitted the Protista had a great resemblance to *Pelomyxa*, which was still further increased by the greyish-brown coloration, the incepted glass-granules, and the great number of nuclei. I succeeded in keeping these shell-less *Difflugiæ* alive in the normal state for nearly three weeks without any trace of a regeneration of the shell being observable. The surface of the protoplasmic body did not present the least excretion or deposition of solid matter; it was rather soft, performed Amœboid movements, and developed pseudopodia until the last, when the Protista became the victims of an unlucky accident.

When I consider that I made my experiments at different times upon a very great number of *Difflugiæ*, that I varied the experiments in every way, and that I carefully observed and examined the individuals operated upon for more than three weeks, I think I may with perfect certainty arrive at the conclusion *that the* Difflugiæ *do not regenerate the shell when injured or entirely removed.*

Polystomella crispa, Linn.

As those forms of Rhizopoda which construct their shell of foreign bodies, such as the *Difflugiæ*, are closely united by a great number of intermediate forms with those which secrete their own shells, such as the Polythalamia, it seemed to me desirable to investigate one of the latter forms with respect to the conditions of regeneration of the shell, and I had afforded to me an opportunity of doing this in the case of *Polystomella crispa*, Linn., from Trieste. These Protista also

I was able to keep alive for two months in watch-glasses with sea-water in which small pieces of Ulvæ were placed to produce the necessary oxygen. As their shells were not very thick, I succeeded very well with them also in effecting divisions and injuries with the lancet in definite places, in which the uncommon viscosity of the protoplasm alone caused some difficulty. In the *Polystomellæ* the nucleus is usually situated in the same part, and, indeed, in the neighbourhood of that chamber upon which the youngest chamber is seated externally. In consequence of this we may know beforehand with some certainty whether we shall or shall not have the nucleus in any separated portion. Of course the portions, after the investigations were completed, were also decalcified with acetic acid and stained with carmine, so that there could remain no doubt as to their containing or not containing a nucleus.

The divisions or mutilations were performed in the following manner. First of all from two to four of the first chambers were removed from some individuals. These amputated chambers showed no phenomena of regeneration, although they remained alive for a long time. In the other portions, however, which contained the nucleus, the irregular broken place was usually repaired again in from three to six days in the following manner:—the protoplasm swelled out in a rounded form somewhat above the spot in question, and on its surface a calcareous layer was secreted (Pl. IX. fig. 4). In its form this calcareous layer resembled the outer wall of the youngest chamber of an uninjured Protistan, and showed the typical structure of the shell of a *Polystomella* perforated by numerous small apertures. The ruins of the tubular system of both sides of the last amputated chamber were not again completed into perfect tubules, but remained in their injured condition, and the newly formed wall had founded itself directly upon them. In one case, however, there were already to be seen upon the outer surface of the newly formed wall the indications of a whole new system of tubules (fig. 5), and this evidently would have been completely developed as soon as a new chamber was founded upon the new wall. The newly formed wall in fact on the two sides, where the tubules are formed in the normal chamber-walls, was perforated by apertures of corresponding size, which were surrounded by a low wall, the indication of the future tubules.

In those individuals in which two chambers were mutilated each chamber did not complete itself separately, but a calcareous layer was secreted only on the surface of the outer of the two cut chambers.

Further, in a number of *Polystomellæ* the last ten or twelve chambers were removed in connexion. The chambers thus removed showed no regeneration in a fortnight, although their vital phenomena were by no means extinguished. They were then killed, decalcified and stained, by which means their want of nuclei was demonstrated with certainty. The remaining portions, on the contrary, showed the same form of regeneration as was first described.

Then some specimens were so cut up that a portion was cut away from a series of chambers. The pieces removed lived on, but also without any phenomena of regeneration. The other portion, in which the nucleus was situated, on the other hand, had deposited over all the incised chambers a common, external, continuous calcareous layer, which completely closed the wound and showed the typical shell-structure (fig. 6).

Lastly, smaller lesions were effected in a series of individuals, triangular notches being made with the lancet in certain places, affecting only one or a few chambers. In a few days these wounds also became covered with a continuous calcareous layer.

It frequently happened that, after the removal of the chambers, the protoplasm became retracted from the last open chamber behind the next chamber-wall. In the case of the other wounds also the protoplasm sometimes drew back into the interior, and then the wounds did not heal. But even after a new calcareous wall had been constructed on an injured chamber, the protoplasm frequently drew back out of this chamber, as, indeed, even in uninjured individuals the youngest chamber or chambers are often quitted by the protoplasm.

In order to determine with still more certainty the influence of the nucleus upon the regeneration of the shell, a series of divisions was made in which enucleate pieces of different sizes were separated. I succeeded in keeping such portions alive for nearly three weeks. Even half of the protoplasmic contents of a single chamber remained alive within the fragment of its shell for a fortnight, when the fragment was killed. *All non-nucleate fragments showed not the smallest trace of new formations*, a phenomenon which stands in the fullest accord with the results of Nussbaum's * and Gruber's †

* "Ueber spontane und künstliche Theilung von Infusorien," in Verh. naturh. Ver. preuss. Rheinl. 1884.

† "Zur Physiologie und Biologie der Protozoen," in Ber. naturf. Ges. zuFreiburg i. B. 1886 (see 'Annals,' ser. 5, vol. xvii. p. 473).

experiments on Infusoria. Nussbaum found that in *Oxytricha* only the nucleiferous fragments became regenerated into new individuals, and Gruber was able by his beautiful experiments to establish the same thing with regard to *Stentor cæruleus*. I may mention here that I have myself repeated Gruber's experiments on *Stentor cæruleus* with the same results, and have also made the same experiments on *Lacrymaria olor*. *Lacrymaria*, of which I had great numbers of individuals at my disposal, was so far a favourable object for these experiments, as it was comparatively easy to detach portions without any fragments of nucleus, which I found to be more difficult with my *Stentors*. However, in *Lacrymaria* I have also obtained the same results, and therefore it seems to me indubitable *that regenerations take place under the influence of the nucleus and cannot be effected without it.*

In *Polystomella* I made a further observation upon the non-nucleate pieces which perhaps will be of interest. I made trial whether the non-nucleate portions take in nourishment by placing in the water containing them numerous small marine Protista which might serve them as food. In clear weather the fragments had extended very abundant pseudopodia, and among these the Protista moved about. I now repeatedly observed that swimming Flagellata remained adherent to the pseudopodia, then made movements to escape, and, when they did not succeed in tearing themselves free, were slowly drawn to the shell with the pseudopodia. With one fragment there were with the Flagellata many specimens of *Euplotes charon* in the same drop of water; but these appeared to be too large to be attacked. When they came near the pseudopodia they always made a quick backward movement which placed them out of danger again. Once, however, I observed that a *Euplotes* which chose to run over a whole bundle of pseudopodia remained attached to several pseudopodia at once, and in spite of its endeavours to escape was slowly drawn towards the shell. During this process its movements became gradually weaker and weaker; soon there were only from time to time a few jerking movements of the posterior cilia, and finally, in about twenty-five minutes, all motion ceased. Some time afterwards, when the fragment changed its place, the Infusorian remained behind, and, as I ascertained, was really dead. I made the same observation another time upon a metabolic *Euglena*.

That inception of nourishment should occur in non-nucleate fragments does not strike me as remarkable, as I have recognized it to be a pure reflex action which only takes place upon mechanical irritation (movement of the food-organisms &c.). I could imitate it by means of artificially moved foreign

bodies, such as paper-fibres &c. But what appears to me to be of importance is the circumstance that the Protista taken up are killed. This distinctly indicates the occurrence of a chemical action on the part of the fragment upon the protoplasm of the food-organisms. Unfortunately in most cases it is very difficult to ascertain whether a digestive process does or does not occur, and therefore I have communicated this observation only because it may perhaps hereafter be made available in connexion with others.

In order to supplement my own investigations upon the phenomena of regeneration in the Polythalamia I will here refer to the observations which Carpenter * had occasion to make on the material of the 'Challenger' Expedition. Among the Foraminifera of the 'Challenger' Expedition Carpenter found some species of the genus *Orbitolites* which were remarkable for their considerable size. One species, which he named *Orbitolites tenuissima*, grows to the size of 0·6 inch, and is characterized by an exceedingly thin and brittle shell. The consequence of this peculiarity was that among the specimens obtained only a few were uninjured; but, on the other hand, there were many which had repaired earlier injuries. Carpenter gives the following description of the mode of reparation :—"When only small portions of the margin are broken away the next-formed annuli extend themselves along the fractured edge; and thus the cyclical mode of growth is completely maintained with only a temporary irregularity." And it is not only small injuries that, according to Carpenter, are repaired in this form, but the power of regeneration goes so far that even small fragments can complete themselves to form perfect individuals, the outer shell-convolutions of which then have exactly the normal constitution. One of Carpenter's figures shows how such a small fragment has completed itself into a perfect individual. Carpenter says of it :—"I have been able to assure myself that every part of the margin of this fragment—whether broken or unbroken, peripheral, central, or lateral—has contributed to the formation of the first new complete annulus, by which the foundation was laid of the subsequent regular series of concentric zones, thus clearly indicating that a sarcodic extension took place from every chamberlet laid open by the fracture, as well as from the normal pores of the last septal plane, and that these extensions coalesced to form a continuous ring, as in the formation of the ordinary succession of concentric annuli. It is most interesting to observe that

* "Report on the Specimens of the Genus *Orbitolites* &c.," in 'Challenger' Report, vol. vii.

the zone of chamberlets to which this sarcodic ring gave origin is formed upon the *perfected type*, without any reversion to the earlier Peneropline stage." The last remark refers to Carpenter's observation that the shell of *Orbitolites* from its earliest foundation passes through various developmental stages, in which it resembles other Polythalamian shells—*Cornuspira*, *Spiroloculina*, *Peneroplis*, and *Orbiculina*. In the same degree as in *Orbitolites tenuissima*, Carpenter also met with the phenomena of regeneration in *Orbitolites complanata*, Lam., a form which is remarkable for the enormous number of its small-chambers and its narrow annuli. Quite a small fragment suffices to induce the new-formation of a large individual. As regards the relations of the nucleus in the *Orbitolites*, Carpenter found in the protoplasmic mass of the Polythalamian a great number of small round corpuscles, which were irregularly scattered. He assumes these to be the nuclei of the Protistan. Moreover, that this Polythalamian form is multinuclear is rendered extremely probable by the intense phenomena of regeneration of the most various fragments.

In conclusion, a brief summary of the results obtained and a critical discussion of them may not be out of place. The result of the observations and experiments on *Difflugia urceolata* is as follows:—The construction of the carapace is effected in the same way as in the other shelled freshwater Rhizopoda, with this difference, that foreign bodies for the structure of the shell are incepted into the protoplasm by certain reflex processes. Regeneration of the injured or completely removed shell by the protoplasmic body does not occur, although the vital functions take their course in the normal fashion. The experiments on *Polystomella crispa* show quite a different result. It appears that phenomena of regeneration are manifested in a fragment if the nucleus is contained in it, but that they never appear when the nucleus is absent. The observed processes of regeneration consist on the one hand in the healing of the wound by a deposition of calcareous matter, which is secreted by the surface of the protoplasm, and on the other in the formation of new chambers. On the contrary, the reparation of separate injured portions, such as, for example, the remains of the tubular system, never took place. In *Orbitolites tenuissima* and *complanata*, finally, the process of regeneration occurs in the same manner, with the sole exception that the formation of new chambers upon

fragments takes place on a much larger scale than in *Polystomella.*

It may be a question what is the reason of the phenomenon that two forms of Rhizopods behave so differently with regard to the regeneration of their shells as *Difflugia* and *Polystomella* or *Orbitolites.* There must evidently be a principial difference between the shells of the two forms which accounts for this difference, and I do not think I am far wrong in finding this in the mode of production of the shells. In *Difflugia,* as in all Monothalamia, the shell originates at the moment of fission, and is completely finished at the separation of the new individual. No subsequent alterations occur, and especially, as Gruber justly notes, no growth of the shell takes place. The protoplasmic body has therefore ceased to have any secretory relations with the shell, the faculty of shell-formation has ceased. In consequence injuries may be inflicted on the shell, or it may be removed altogether, without the occurrence of any regeneration.

The conditions are different in the production of the Polythalamian shells. It must now be regarded as proved by a number of observations that the Polythalamia reproduce by a kind of spore-formation, although this process has not yet been directly observed. At any rate we know that the young Polythalamia occur within the body of the parent as unilocular Protista. If these develop into perfect Polythalamia, they form upon the original chamber a new one, to which another new one is soon added, and so forth. From this it follows that the Polythalamia, so long as they form new chambers, must have the faculty of shell-secretion. The reason that existed in the case of *Difflugia* for the cessation of the shell-secretion no longer exists here, and, in fact, the Polythalamia do regenerate their shells. A natural consequence of this mode of formation of the shell in the Polythalamia is the phenomenon that the forms with comparatively limited chamber-formation, such as *Polystomella,* possess the faculty of regeneration in a much less degree than the forms with an exceedingly strong chamber-formation, like *Orbitolites.* The faculty of regeneration in the Polythalamia is therefore proportional to the faculty of forming new chambers, and the latter again indicates the duration of development; consequently the power of regeneration certainly persists throughout the whole period of development. Gruber characterizes the addition of new chambers only as a growth, and says, on another occasion *, that in the Protozoa in general

* "*Dimorpha nutans,* eine Mischform zwischen Flagellaten und Heliozoen," in Zeitschr. f. wiss. Zool. Bd. xxxvi.

we cannot speak of a development. I cannot adopt this view, for I certainly see in the chamber-formation of the Polythalamia a process which is no mere growth, for the chambers are not equal and similar, and the Protistan has quite a different appearance when it has only a few chambers, and later when it has many. This process seems to me much rather to represent a true development, and I even believe that in particular forms of shells this development will prove to be available for the recognition of their phylogenetic relations.

With regard to the relation between the faculty of regeneration and development, it would moreover be of interest to examine in the case of very old individuals whether the power of regeneration has also sunk to zero, as we must assume to be the case. Further, it would be very desirable to test such forms as *Orbulina* &c., which remain unilocular throughout their lives, as to their regenerative faculty. At any rate we should here meet with similar conditions to those prevailing in the Monothalamous freshwater Rhizopoda.

The demonstration of the influence which the nucleus exerts in the regeneration of the shell in *Polystomella* seems to me to be of particular importance. Of late much attention has been directed to the action of the cell-nucleus; but, although many naturalists have made observations upon its functions, our knowledge of the matter still remains rather limited. Besides the relations to reproduction which the cell-nucleus displays, it has been endeavoured recently to investigate its influence upon direct processes of change of material, and the function of secretion especially has been claimed for it. In the epithelial cells which secrete the chitinous rays of the egg of *Nepa* and *Ranatra*, Korschelt * observed that at the period of secretion the nucleus acquires a peculiar Rhizopodoid form, and emits pseudopodium-like processes towards the side on which the chitinous secretion takes place. He further convinced himself that all cells in which branched nuclei are known to occur have a secretory character. As, however, hitherto there was no direct observation of the share taken by the nucleus in the secretory activity of the cell, it is particularly interesting to become acquainted with such a case in the regenerative processes of the Polythalamia.

* Tageblatt der 59. Versammlung Deutscher Naturforscher und Aerzte in Berlin; No. 5. Sitzungsb. der Sekt. für Zoologie. Korschelt, "Die Bedeutung des Kernes für die thierische Zelle," in Sitzungsb. d. Ges. naturf. Freunde zu Berlin, No. 7, 1887.

EXPLANATION OF PLATE IX.

Fig. 1. *Difflugia urceolata*, Carter, engaged in division and shell-formation. The new shell composed of fragments of glass.

Fig. 2. The same, with half the shell removed. In the endoplasm besides sand-grains there are a number of red nuclei (here black).

Figs. 3 *a*, *b*, *c*. Shells of *Difflugia urceolata* divided in various directions indicated by the dotted lines.

Fig. 4. *Polystomella crispa*, Linn. The youngest chambers have been removed and a new calcareous wall has been formed over the lesion.

Fig. 5. The same, showing the regeneration on a large scale. *a*, from the side; *b*, from in front.

Fig. 6. The same, with six chambers partially removed, and with a common calcareous layer deposited over the cut surface.

XX.—*The Species of the Genus* Urodacus *contained in the Collection of the British (Natural-History) Museum.* By R. I. Pocock, Assistant, Natural-History Museum.

[Plate VIII.]

This genus was described by Peters in 1861. It differs from other Scorpions, which are characterized by the possession of a pentagonal sternum and two lateral eyes, by the presence of a median keel upon the lower surface of each of the caudal segments.

Urodacus novæ-hollandiæ, the type of the genus and hitherto its sole representative, was described by Peters (Monatsber. d. k. Akad. Wissen. Berlin, 1861, p. 511) from specimens obtained from West Australia; and Count Keyserling, in his work 'Die Arachniden Australiens,' p. 34, has published a lengthy description of it, the description and accompanying figure (Pl. VIII. figs. 1, 1 *a*) being taken from specimens also from West Australia.

Whilst examining for identification the Scorpions contained in the collection of the British (Natural-History) Museum, I found that this genus *Urodacus* is represented by no less than four well-marked species. Three of these I believe to be new to science, and have consequently described; the fourth I refer to *U. novæ-hollandiæ* of Peters.

Of this last-named form the Museum possesses eleven specimens, a series which presents some interesting and, I believe, new facts connected with the sexual variation and the geographical distribution of the species.